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(54) A PRE-ALLOY POWDER FOR THE MANUFACTURE OF ALLOYED SINTERED STEEL WORKPIECES

(71) We, GFE GESELLSCHAFT FÜR ELECTROMETALLURGIE MBH a German Company of 4000 Düsseldorf 1, Grafenberger Allee 159, Federal Republic of Germany do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention generally relates to a pre-alloy powder for the manufacture of alloyed sintered steel workpieces, in which manufacture a ferro-alloy is first produced from the alloy elements required in the sintered steel workpieces together with iron and carbon, this is pulverised and milled to a pre-alloy powder, the pre-alloy powder is mixed with ductile iron powder, and the mixture is pressed and sintered.

The manufacture of tool steels and high speed steels from ferro-alloys is relatively new. So far as other steels have been manufactured by powder metallurgy, one has worked with fully alloyed materials manufactured by the melting method and subsequently converted by spraying into the necessary powder form. These alloy powders possess the complete composition of the steel that is to be sintered, but have the disadvantage of a considerable oxygen content. The oxygen content affects the mechanical properties of the finished workpieces. Moreover very high pressures are necessary for pressing, greater by a factor of 2 than the pressure normal in iron powder metallurgy. If one works with lower pressures, the tensile strength values achieved are insufficient. Steels which contain manganese and chromium and/or vanadium are not at all practicable to make in the manner described. In fact it is very difficult to avoid oxidation of the alloyed chromium or manganese with the sintering atmosphere used in practive. A reduction of oxides introduced by these alloying elements cannot be accomplished in furnaces used for the sintering technique. At least if one attempts to work with manganese and chromium and/or vanadium-additions, the tensile strengths achieved by the known process are for this reason inadequate.

According to the present invention a pre-alloy powder for the manufacture of alloyed sintered steel workpieces comprises a pulverized ferro-alloy comprising manganese and chromium or manganese and vanadium in the form of complex metallic carbides, with a grain size less than 10 μm, having an oxygen content of less than 0.2% and resistant to oxidation at temperatures in the region of 1200°C.

Pressing forces normal in iron powder metallurgy, are about 500 MN/m². Preferably the sintering temperature is up to 1280°C.

Within the scope of the invention complex metallic carbides signify carbides

of at least two of the given elements and iron, mostly in the form of solid solutions.

The invention depends upon the surprising fact that a ferro-alloy consisting of the given complex metallic carbides, when pulverised, does not absorb oxygen, or at least does not do so to a troublesome extent. Therefore the pre-alloy powder, when a protective fluid is used in grinding to a grain-size below 10 μm, preferably below 5 μm, can without difficulty be limited to an oxygen content below 0.2%, preferably less than 0.15% even if it is milled extremely finely. The pre-alloy powder which is to be used for the manufacture of a sintered workpiece possesses a quite surprising resistance to oxidation, even at temperatures up to 1200°C and more. Difficulties caused by high oxide content of the powder which is to be pressed and sintered to form steel workpieces, and the influence on the tensile strength of the manufactured sintered steel workpieces are eliminated no longer occur. It can be accepted that the complex metallic carbides of manganese plus chromium, or of manganese plus vanadium, effect an additional protection against oxidation. This is also valid with extremely fine milling. It has been found that the alloy elements diffuse very readily during sintering, so that a very homogeneous distribution of the elements is achieved in the finished sintered steel workpiece which has a beneficial effect on the mechanical properties e.g. on tensile strength and hardenability. Examples of ferro-alloy powder and analyses of ferro-alloy powders which are particularly suitable for manufacturing sintered steel workpieces are in % by weight:—

20—25% Manganese
20—25% Chromium
4— 8% Carbon
Balance iron

with impurities due to melting

30—35% Manganese
35—45% Chromium
5— 7% Carbon
Balance iron

with impurities due to melting.

20—25% Manganese
20—25% Chromium
20—25% Molybdenum
6— 8% Carbon
Balance iron

with impurities due to melting.

20—25% Molybdenum
20—25% Vanadium with or without Niobium
20—25% Manganese
Up to 7% Carbon
Balance iron

with impurities due to melting.

In the following is illustrated the use of the pre-alloy powder of the invention in terms of examples of its performance.

EXAMPLE 1

In manufacturing a sintered steel workpiece which contains as alloy elements manganese plus chromium and also molybdenum, normal commercial iron powder is thoroughly mixed with a complex metallic carbide powder according to the invention in proportions of 96% to 4% and pressed as a workpiece e.g. a gearwheel, with a pressure of 500 MN/m^2. The complex metallic carbide powder contains 21% Cr, 20.8% Mn, 23.1% Mn and 7.8% C, balance Fe.

The milling of the complex metallic carbides took place in an attritor to an FSSS (Fischer Sub-sieve sizes) grain size of 3 μm. the oxygen content of the powder amounted to 0.16%. (Fe, Mn, Cr)$_7$(C_3 and β-Mo_2C were identified in the carbide phases. Sintering took place at 1250°C in a normal sintering furnace, e.g., in a rocker bar heating furnace with a cracked ammonia atmosphere. A test during the sintering process proved that up to 1200°C there was no oxidation of the metallic carbide powder, which, beginning at 1100°C, dissolved easily and completely by 1250°C. in the iron powder.

Example 2

In manufacturing a sintered steel workpiece which contains the alloy elements manganese plus vanadium plus molybdenum, normal commercial iron powder is thoroughly mixed with a complex metallic carbide powder according to the invention in proportions of 97% to 3% and pressed to the desired workpiece with a pressure of 500 MN/m^2. The complex metal carbide powder contained 21% Mn, 22% Mo and 21.4% V, also 7.9% C balance Fe.

The manufacture of the powder again took place by fine milling in an attritor. The FSSS grain size amounted to 5 μm, with an oxygen content of 0.19%. As carbide phases were found: VC—Mo_2C solid solutions, and the M_7C_3 type in which M is chiefly iron and manganese.

Sintering took place at 1280°C in a cracked ammonia atmosphere. Again with the complex iron alloy carbide powder used here no oxidation could be conformed up to 1200°C.

WHAT WE CLAIM IS:—

1. A pre-alloy powder for the manufacture of alloyed sintered steel workpieces comprising a pulverized ferro-alloy comprising manganese and chromium or manganese and vanadium in the form of complex metallic carbides, with a grain size of less than 10 μm, having an oxygem content of less than 0.2% and resistant to oxidation at temperatures in the region of 1200°C.

2. A pre-alloy powder as claimed in Claim 1, wherein the grain size is less than 5 μm.

3. A pre-alloy powder as claimed in Claim 1 or Claim 2, wherein the oxygen content is less than 0.15%.

4. A pre-alloy powder as claimed in any preceding Claim, consisting of by weight:—

20—25% Manganese
20—25% Chromium
4— 8% Carbon
Balance iron

with impurities due to melting.

5. A pre-alloy powder as claimed in any one of Claims 1 to 3 consisting by weight:—

30—35% Manganese
35—45% Chromium
5— 7% Carbon
Balance iron

with impurities due to melting.

6. A pre-alloy powder as claimed in any one of Claims 1 to 3, consisting of by weight:—

20—25% Manganese
20—25% Chromium
20—25% Molybdenum
6— 8% Carbon
Balance iron

with impurities due to melting.

7. A pre-alloy powder as claimed in any one of Claims 1 to 3, consisting of by weight:—

20—25% Molybdenum
20—25% Vanadium with or without Niobium
20—25% Manganese
Up to 7% Carbon
Balance iron

with impurities due to melting.

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